REMARKS:

1) We have not yet received an acknowledgment of applicants' Information Disclosure Statement filed with this application on December 18, 2001. The Examiner is respectfully requested to consider the references, and to return an initialed, signed and dated copy of the IDS Form PTO-1449 of December 18, 2001, together with the next official communication.

2) Referring to item 10) of the Office Action Summary, a drawing correction is not needed, because instead the specification has been amended as will be discussed below.

3) In accordance with the PCT procedures, the original specification of this application was a Literal Translation of the corresponding PCT International Application. The specification has now been amended editorially and formally to better adapt the text to typical U. S. application form, to correct a few typographical errors and the like in the original PCT text, and to improve the readability of the translation by making it somewhat less "literal". Also, the reference numbers **60** and **63** have been added to the specification at page 5, lines 3 and 4, to correspond to drawing Fig. 1. These editorial and formal amendments, and the introduction of reference numbers into the specification as supported by the original disclosure of the drawings, do not introduce any new matter. Entry of the amendments is respectfully requested.

4) The claims have been amended as follows. Claims 7, 9 and 10 have been editorially amended to more clearly refer to the "variations" of the spring forces rather than the "progressions" of the spring forces. This clarification is supported by the original disclosure of Figs. 2 and 3 and the corresponding description thereof. Therefore, the claim amendments do not introduce any new matter. Entry and consideration of the claim amendments are respectfully requested.

5) New claims 11 to 20 have been added. Independent claim 11 is directed to the electromagnetic actuator device, claims 12 to 15 are device claims depending from claim 11, and claims 16 to 20 are method claims directed to a method of adjusting the electromagnetic actuator of claim 11. The new claims 11 to 20 have been drafted "from the ground up" as a fresh approach at covering the inventive subject matter with a slightly different claim style, format and terminology relative to the original claims, as a matter of personal claim drafting preferences. The new claims 11 to 20 are supported by the original disclosure as shown in the following table, and do not introduce any new matter. Entry and consideration of the new claims are respectfully requested.

New Claims	**11**	**12**	**13**	**14**	**15**
Original Support	**Cl.1**	**pg.7, ln.22-23**	**pg.7, ln.19-23; Fig.2**	**pg.7, ln.19-23; Fig.2**	**pg.7, ln.11-16; pg.9, ln.1-20**

New Claims	16	17	18	19	20
Original Support	Cl.7	pg.7, ln.11-16; pg.9, ln.1-20	pg.9, ln.3-4	Pg.8, ln.22- pg.9, ln.20	pg.7, ln.19-23; Fig.2

6) Referring to the second paragraph on page 2 of the Office Action, the objection to the drawings has been obviated by the present amendment of the specification at page 5, lines 3 to 4. Namely, reference numbers **60** and **63** are now described in the specification, so that the specification conforms to the drawings. The Examiner is respectfully requested to withdraw the objection to the drawings.

7) Referring to the bottom of page 2 and the top of page 3 of the Office Action, the suggested guidelines for the format of a U. S. application have been taken into consideration in the present amendment of the specification. Accordingly, the Examiner is respectfully requested to withdraw any objection to the specification.

8) Referring to the middle of page 3 of the Office Action, the rejection of claims 9 and 10 as indefinite under 35 U.S.C. §112, second paragraph has been taken into account in the present amendment. The term "progressions" has been clarified by instead referring to "variations of the spring forces" especially in connection with the compression of the springs over the stroke travel distance. It is respectfully submitted that all claims

now particularly, distinctly and clearly claim the subject matter regarded as the invention, and the Examiner is respectfully requested to withdraw the rejection.

9) Before addressing the prior art rejections and comparing the particular claimed features of the invention to the prior art disclosures, the invention will first be discussed in general terms to provide a background.

The invention generally relates to an electromagnetic actuator including conventional components such as an armature that is movable back and forth between two electromagnets against the force of two opposed resetting springs. The special features of the invention relate to the particular pre-adjustment of the springs, in both an actuator arrangement as well as an adjusting method for the actuator arrangement.

As the armature is actuated to move back and forth between the electromagnets by the alternate energizing of the electromagnets, it is desirable to achieve a rapid and positive back-and-forth actuation of the armature, while minimizing the electrical power consumed by the electromagnets, minimizing the variation of the power consumption dependent on manufacturing tolerances or variations of the actuators, and minimizing the impact of the armature against the electromagnets at the ends of the travel stroke of the armature.

The prior art has provided various arrangements and methods for pre-adjusting an actuator apparatus in order to try to achieve at least some of these goals. For example, the prior art methods and arrangements for adjusting an electromagnetic

actuator involve adjusting the resting position of the armature (with de-energized electromagnets), and/or adjusting the pre-load or pre-stressing of the springs (e.g. to the same pre-stressed value). Such prior art efforts have not been completely successful, however, because they fail to take into account unavoidable variations in the spring characteristics of individual springs.

Every spring is characterized by its own particular spring characteristic which defines the variation of the spring force over the course of the spring travel as it is compressed. Due to unavoidable variations, such as production tolerances (e.g. in the dimensions of the spring), variations in the material of which the spring is made, etc., each spring has its own unique spring characteristic that necessarily differs from the spring characteristic of other springs, even for two springs that are nominally of the same type. In other words, if two springs of the same type are precisely tested, it will be found that these two springs actually have different spring characteristics, even though the two springs are nominally the "same".

Furthermore, it can be desirable to purposely use two different springs having two different spring characteristics in an electromagnetic actuator of the present relevant type. For example, when such an actuator is used for actuating a gas exchange valve in an internal combustion engine, there are different forces acting on the valve in the opposite opening and closing directions. Namely, the gas pressure in the cylinder (which tends to close the valve), the gas flow through the valve (which tends to open the valve), and other influences exert

different forces in opposite directions on the valve. Therefore, to achieve an optimum operation of the valve, it is advantageous to arrange different springs having purposely different spring characteristics on opposite sides of the valve actuator armature.

The total energy stored by a compressed spring is given by the integral of the varying spring force over the spring travel distance as the spring is compressed. Thus, the stored spring energy is influenced by the spring force (and particularly the varying spring force defined by the particular spring characteristic of this spring), and the compressive spring travel (which relates to the "position" of the armature or of the end of the spring itself), as well as any pre-stressing load that has been applied to the spring. Only by considering all of these factors is it possible to address and adjust the total spring energy stored in the spring, particularly to achieve the same energy stored in the two opposed springs of the actuator by appropriately pre-stressing at least one of the springs. On the other hand, merely setting the same spring pre-stress, or a centered neutral position, or the same impact force of the two springs, cannot evaluate and achieve the same spring energy stored in the two springs, especially because this would not take into account the different spring characteristics of the two springs.

The prior art neither discloses nor would have suggested the presently claimed inventive features, as will be discussed next.

10) Referring to the top of page 4 of the Office Action, the rejection of claims 1 to 3 as anticipated by U. S. Patent 6,176,208 (Tsuzuki et al.) is respectfully traversed.

11) Present claim 1 is directed to an electromagnetic actuator having two springs acting oppositely on an armature, wherein the springs are pre-stressed so that <u>the same **energy** is stored in both springs</u> when the springs are respectively compressed through a spring compression travel prescribed by the stroke travel distance of the armature. Tsuzuki et al. does not disclose and would not have suggested pre-stressing the springs in this manner so that <u>the same **energy**</u> is stored in both springs.

12) Tsuzuki et al. disclose an electromagnetic actuator having components and an arrangement generally corresponding to that of the present invention. However, <u>the pre-stressing of the springs according to Tsuzuki et al. is significantly different from that of the present invention</u>.

The Examiner has asserted that the two springs according to Tsuzuki et al. are pre-stressed in such a manner so as to store the same amount of energy, citing col. 4, lines 52 to 55. The Examiner's assertion is respectfully traversed as being factually incorrect. Actually, Tsuzuki et al. disclose that "*The <u>biasing force</u> of both springs 21, 22 is set at an <u>equal value</u>, and the armature 6 takes a <u>position</u> which is substantially a <u>center</u> of the space between solenoids 51 and 52 when neither solenoid is energized*" (col. 4, lines 52 to 55, emphasis added). Thus, the pre-stressing adjustment according to Tsuzuki et al. achieves <u>the</u>

same biasing **force** of both springs (see col. 2, lines 10 to 11; col. 4, lines 52 to 55; etc.) rather than the same **stored energy**.

The biasing force of a spring is not the same thing as, and does not suggest the total energy stored in the spring when it is compressed. Rather, the stored energy is given by integrating the varying spring force over the spring compression travel, for example, and must take into account the spring characteristic of the spring. Thus, as generally discussed above, an adjustment to achieve the same pre-biasing force when the springs are in a neutral centered condition does not disclose or suggest an adjustment to achieve the same stored energy when the springs are in a compressed state.

Tsuzuki et al. do not take into account and do not suggest anything about differences in the spring characteristics of the two springs, and do not consider or suggest anything about the total energy that is stored in each spring when the respective spring is compressed. As discussed above, there will always be differences in the spring characteristics of the two springs (e.g. due to production tolerances and the like), even if the two springs are nominally of the same type. Without taking the spring characteristic or variation of the spring force over the spring compression travel into consideration, it is not possible to achieve or suggest that the same energy is to be stored in both springs when they are respectively compressed.

To the contrary, if the two springs are pre-stressed so that they apply the same or equal biasing **forces** in a neutral centered condition, it would be expected that the total **energy** stored by the two springs in the respective compressed condition thereof

would <u>**NOT** be equal</u> in view of differences of the spring characteristics of the two springs.

For the above reasons, Tsuzuki et al. do not expressly or inherently disclose a pre-stressed condition of the springs such that the same <u>energy</u> will be stored in the springs when the springs are respectively compressed. Also, a person of ordinary skill in the art would have found no suggestion toward such a feature of the invention, because Tsuzuki et al. <u>give no consideration of variations of the spring characteristic</u> (i.e. the variation of the spring force over the compression travel distance of the spring), so that <u>the total stored energy of the compressed spring would be totally unknown and undeterminable</u>.

To the contrary of the teachings of Suzuki et al., the inventive arrangement will actually provide <u>different</u> pre-bias <u>forces</u> of the two springs, and an <u>un-centered</u> neutral rest position of the armature between the electromagnets, to account for different spring characteristics of the two springs (e.g. as apparent from the different pre-stress forces F10 and F20 and the un-centered resting position Ie in the example of present Fig. 2).

13) For the above reasons, the Examiner is respectfully requested to withdraw the rejection of claims 1 to 3 as anticipated by Tsuzuki et al.

14) Referring to the bottom of page 4 and the top of page 5 of the Office Action, the rejection of claims 1 and 7 to 10 as

anticipated by U. S. Patent 5,822,167 (Schmitz) is respectfully traversed.

15) The important features of claim 1 have been discussed above. Namely, claim 1 requires that the springs of the actuator are pre-stressed in such a manner so that the same **energy** is stored in both springs when the springs are compressed.

16) Schmitz discloses an actuator with components generally corresponding to those of the present inventive arrangement, but with a significantly different adjustment of the springs.

Contrary to the Examiner's assertion, the two springs of the actuator of Schmitz are **NOT** pre-stressed so that they both store the same amount of energy in the compressed condition.

Rather, Schmitz discloses adjusting at least one of the two springs "*to thus adjust the axial location where the forces of the counteracting spring 7 and 8 are in equilibrium*" (col. 4, lines 3 to 6, emphasis added). Schmitz further discloses that the pre-adjustment is carried out so that the armature (5) "*is held in a mid position between the two electromagnets 3 and 4*" (col. 3, lines 63 to 67). These teachings relate to adjusting the equilibrium or rest **position** of the armature and the springs connected thereto, and do not suggest anything about the **energy** stored in the springs in the compressed condition thereof.

Further, Schmitz discloses adjusting at least one of the springs to adjust the rest position of the actuator so that the **impact force** of the armature striking against the two opposite electromagnets is equal to a desired value in both directions,

i.e. against both electromagnets (see abstract; col. 3, lines 10 to 25; etc.). The main goal of Schmitz is not to ensure that the same energy is stored in both springs when the springs are compressed, but rather to achieve the same impact force of the armature against the electromagnets at the ends of the armature travel:

In this regard, the impact force is not the same thing as and does not directly correspond to the stored energy of the spring. To the contrary, the impact force of the armature against the electromagnets is influenced by many factors other than the stored spring energy, such as the driving force characteristic of the respective electromagnet, the particular electrical energizing cycle of the electromagnet, the gas pressure and flow conditions acting on the valve, the frictional resistance of the valve, the progressive nature of the spring characteristic, etc. (see col. 1, line 63 to col. 2, line 37; and col. 5, lines 8 to 17).

Schmitz neither discloses nor suggests determining or even taking into account the spring **energy** that is stored in the respective spring when the spring is compressed. Instead, Schmitz merely measures the **impact force** of the armature at the end of its travel striking against the respective electromagnet, and adjusts the **rest position** of the armature to achieve the desired impact forces. This neither expressly nor inherently discloses an adjustment of the spring pre-stress to ensure that the same energy will be stored in both springs in their compressed conditions.

Moreover, a person of ordinary skill in the art would have found no suggestion or motivation to even consider the amount of energy stored in the two springs, and taking adjustment steps so as to balance or equalize the stored energy of the two springs, because instead, the reference leads away from such considerations by suggesting to measure the impact force of the armature (which does not directly correspond to the stored spring energy for the reasons discussed above).

Regarding present dependent claims 9 and 10, the measuring means and control means disclosed by Schmitz are not for measuring the variations of the spring forces of the springs over the stroke travel distance and controlling the setting means in accordance with the measured spring force variations, but rather are for measuring the impact force and then controlling the adjustment of the springs based on the measured impact force.

17) Present independent claim 7 is directed to a method for adjusting an electromagnetic actuator, comprising measuring the variation of the spring force for each spring while the spring is compressed through a spring travel distance, then determining the energy stored in the respective spring due to the compression thereof from the measured spring force variation, and then pre-stressing at least one of the springs so that the same energy is stored in both springs. Schmitz neither discloses nor would have suggested such a method.

18) As discussed above, Schmitz discloses a method that involves measuring the impact force of the armature striking against the

respective electromagnet, and then adjusting at least one of the springs to move the resting position of the armature and achieve desired or balanced impact forces of the armature against the two electromagnets.

Schmitz does not disclose and would have had no purpose for measuring the spring force variation of each spring over the compressive travel stroke thereof and then determining the total energy stored in the respective compressed spring. Schmitz does not disclose or suggest anything about determining the total energy stored in the compressed spring.

For example, the total energy stored in the spring can be determined by integrating the varying spring force over the spring compression distance thereof. Schmitz does not disclose or suggest such integration or any other method for determining the total stored energy of the spring. Therefore, Schmitz does not disclose and would not have suggested a method including such method steps of determining the stored energy of each spring and then pre-stressing at least one of the springs so that the same energy is stored in both springs.

Contrary to the teachings of Schmitz, the present inventive method would not result in a neutral static resting position of the armature midway between the two magnets with equal spring bias forces, but rather would provide different pre-stress forces and an un-centered rest position of the armature, in consideration of different spring characteristics of the two springs (as discussed above). Also, the adjustment based on the impact forces would not be expected to achieve the same stored energy in the two springs, in view of the above-discussed

differences in the other influences on the impact force as recognized by Schmitz, such as the different frictional resistance, the different gas pressure and flow conditions acting on the valve, the different driving force characteristics of the two electromagnets, etc. All of such factors are "lumped into" the resulting impact force, while the invention takes into account purely the stored energy of the respective springs.

19) For the above reasons, the Examiner is respectfully requested to withdraw the rejection of claims 1 and 7 to 10 as anticipated by Schmitz.

20) The additional prior art made of record requires no particular comments because it has not been applied against the claims.

21) The new claims 11 to 20 are patentably distinguishable over the prior art for similar reasons as discussed above.

Claim 11 is directed to an electromagnetic actuator, wherein the two springs are pre-stressed so that the same total spring energy is stored in each one of the springs when the springs are maximally compressed. As discussed above, the applied references neither disclose nor would have suggested such a pre-stressing of the two springs to achieve the same total stored spring energy.

Claim 12 recites that the two springs have two different spring characteristics, which is a feature not addressed by the references in the present context.

Claims 13 and 14 recite that a rest position of the armature is not at a geometric center of the spacing distance between the two electromagnets, which is contrary to disclosures of the references (especially Tsuzuki et al.) relating to a centered rest position.

Claim 15 recites that the same total spring energy of the two springs is given by an integral of the spring force over the spring travel of the respective spring. The references are silent in this regard.

Claim 16 is directed to a method of adjusting the electromagnetic actuator, including steps of measuring the spring force variation over the spring travel of each spring, determining a spring energy stored in each spring from the measured spring force variation, and then pre-stressing at least one of the springs to adjust the spring energy thereof so that the spring energy stored in both springs will be equal. For the reasons discussed above, the references would not have suggested such method steps.

Claims 17 and 18 recite that the spring energy is determined by integrating the measured variation of the spring force over the spring travel of each respective spring. The references would not have suggested such an integrating process.

Claim 19 recites a preliminary step of pre-stressing one of the springs to a prescribed value, and then adjusting the other one of the springs so that the respective stored spring energies match. The references would not have suggested such a process.

Claim 20 recites that the spring force variations differ in the two springs, and the adjusted rest position is not centered

between the two electromagnets. This is contrary to pertinent reference teachings as discussed above.

22) Favorable reconsideration and allowance of the application, including all present claims 1 to 3 and 7 to 20, are respectfully requested.

Respectfully submitted,

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